SCIENCE IN COMMERCIAL WORK: ITS PRACTICAL VALUE, CHARACTER, AND PLACE IN HIGH-SCHOOL WORK.

THE course of study of any high school should be along broad lines. Courses of study should be fitted to the pupil, and not the pupil to the courses of study. Although earning a living is one of the primary aims of everyone, and although of those who attend the high school nearly all follow commercial pursuits, the aim of any course is to start the pupil on the way to an education. In framing such a course, there is little to guide us; for, while the school programs of France and Germany are suggestive, it must be borne in mind that the boys of those countries are in many ways unlike the American boy. With them the school is the main end of their life, is a business—a serious business. The text-book, assimilated by the memory under pressure (there is comparatively little laboratory work in any subject), and a complete devotion to the school account for the apparently rapid advancement of the French or German boy. A widely traveled French engineer, M. Jules Picard, after a long residence in this country, remarked that the American student at twenty is two years behind the French student of the same age; at forty, the Frenchman is far behind the American.

Almost everything, from wearing apparel to heavy machinery, is made to order in Europe, and, because of the low cost of labor and the high standard of skill in hand-work, at prices that defy competition. We manufacture; and in manufacturing alone, and not in making to order, can we compete with the European. There are a few things we need to imitate in their business and manufacturing methods. The commercial supremacy of the German in many lines of business is in part due to the earnest way in which the business man prepares himself for his work.

The system of election in studies is with us an accepted fact, and election by subjects is growing more in favor than election

by courses. In election by courses the opportunity for selection comes early in school life; in election by subjects the opportunities for exercising a choice increases year by year. The separation of a high-school system into English, classical, manual training, and commercial schools forces the child of fourteen, or his parents, to choose a course in which there is comparatively little election. If the commercial high school is not large enough to include a great variety of subjects, there should be considerable flexibility in changing from one school to another. There can be no true election without such flexibility. Boys at work develop tastes for different lines of business; and boys at school should be given opportunity to change their direction without returning to the port from which they started.

School programs, good ones at least, grow and are not manufactured. The times change, and our program of study must change with them. While there are certain principles that must be kept in view in laying out courses of study, the final test must, as in everything else, be sought for in the results produced. There has been an almost total lack of intentional experimentation with school programs. The great variety we have today has come from the desire to find the final and best course, rather than to establish different courses and to study and observe the results. We may assume that courses, and the subject-matter taught in them, will change more rapidly in the future than in the past. Experiments are best made in the upper classes. Almost all the enrichment of the secondary schools has been introduced in the colleges, and then put earlier and earlier in the course.

The method of science instruction, as well as the content, must be considered. What can be taught is more or less influenced by the method of presentation. The method of teaching one pupil at a time, known as individualism, is much more common in science than in other branches. Individualism in science requires the rotation order of laboratory exercises. It is enough to say of this that all teachers who follow this plan seem themselves doubtful of the value of laboratory work. Individualism has proved itself of use in the commercial college, where,

accompanied with much class work, it was used years ago. If individualism means, as it does in the commercial college, that a pupil must attain a certain standard of proficiency, then individualism should be a part of our system of secondary education. This certain standard is the one which, for the chosen profession in life and for the successful progress in the same study or in allied subjects, is the best; for there is, we must remember, such a thing as over-learning. Individualism is here considered as a standard below which a pupil must not fall, and this standard will vary according to the pupil and the use to which his knowledge and training is to be applied in school or in after-life, rather than as a license for the pupil to go his own gait. Let the rapid pupil find work in a large number of subjects, rather than in an increased rate of progress in any one. At the secondary-school age, as at perhaps any stage in life, a lapse of time must be allowed for that unconscious mental cerebration that makes knowledge and acquired skill a part of our own being.

The success of science-teaching depends on the co-operation of other departments: co-operation of the modern-language department, by teaching scientific French and German; of the English department, in dictation and notebook records; of the art department in the use of drawings, diagrams, and lettering, and the general attractive and self-explanatory appearance of the notebook pages; of the manual-training department, in the construction of models and apparatus. In the same way, instruction in science should be helpful to the commercial branches.

The reform in mathematical teaching is well under way. The simpler and more practical teaching of mathematics, in part using the work in science for concrete work, might be tried in commercial high schools, unhindered by tradition and college-entrance requirements. It is recognized that a much less theoretical knowledge of algebra, geometry, and trigonometry than is current today would be helpful in science-teaching. Much of plane geometry, as far as inscribed angles, might be assumed. Interest in formal demonstration is fully aroused when we prove something that is not at all obvious. Is any principle of business

violated if the pupil's attention is called to the fact that one, and only one, perpendicular can be drawn from a point to a line? Examples and problems might bring out important facts: that the power of the tides everywhere, and solar engines in most places, is more expensive than power from steam or gas engines; that wherever the barometer is low, as on the elevated plateaus of the West, air compressors work less efficiently, and the addition of a condenser to a steam engine gives less economy, than at the sea level.

Science should be studied as a whole, and not as if composed of unrelated branches. There has been too much separation of physics and chemistry. There is no neutral zone. Portions of physics—electrolysis, batteries, energy of combustion—are just the places where a little time is well spent on chemical theory and chemical experiments. Chemistry without some knowledge of density, methods of electrical measurement, and the whole subject of heat, is at times unintelligible. Chemistry, physics, biology, and physical geography are difficult subjects. It is impossible to make them easy and at the same time valuable as training or information. Science should not be a playground or an asylum for the lazy, the mentally weak, or those who cannot or will not learn languages and mathematics. A fact to be of use to a business man must not be associated with the particular branch in which it is usually taught. If the pupil learns that different countries have different climates, he should not, as did Lord Timothy Dexter, of Newburyport, send warming pans to the West Indies; the fact that this proved a profitable venture, because they were used as molasses strainers, was only an unusual case of good luck.

The course in science should have in each year such portions of each branch of science as are supposed to be adapted to the progress of the pupil—a spiral arrangement, each year going farther into and taking up the more difficult portions of each subject. Physics, chemistry, meteorology, physical geography, and biology, including quantitative laboratory work, would then form a part of each year's course. Chemistry should be taught from the energy standpoint. Even if cadmium is omitted, teach

something about tungsten, titanium, and molybdenum; for these by no means rare metals, with iron free from carbon, form alloys that hold an edge at a red heat. By their use iron and steel will be worked from two to five times as fast as before. The new abrasive, and other products of the electric furnace and electro-chemical processes of manufacture, enough blowpipe work in the determination of minerals to get a comprehension of how this work is done, and other work of a practical nature, should be included in the course. The manufacture of a few chemicals, keeping a careful account (perhaps with the co-operation of the bookkeeping department) of the cost of raw materials, rent, labor, depreciation of apparatus—an item brought home to the student by the laboratory fee and breakage bill—gives an idea of what is known to manufacturers as "costing." The construction and cost of producing electric current from galvanic cells, as determined by actual tests, show how inefficient zinc is as fuel for generating power in large amounts; the measurement and calculation of the horse-power of engines and motors, and practice with the photometer, are good preventives of the craze for perpetual motion. There is no place for Aladdin's lamp in the business world. The millions that are wasted yearly in foolish ventures, which would not be considered for a moment by anyone who had studied science and had an idea of the laws of conservation of energy, would, if turned into the channels of legitimate business, make America the foremost commercial nation in the world.

The work in science should be practical. In specific gravity, weigh something besides blocks: take the native rocks, specimens of minerals, coal, the common metals, and wood in common use. In heat, learn the names and uses of actual working instruments—the pyrometer, ecometer, safety valves, calorimeter—always using the commercial names of things. Study the catalogues of trade supply houses, plumbers, and steam-fitters, the trade journals and scientific magazines, and consular reports. Call attention to the economic value of inventions, and the way we do things now as compared with a century ago, when there were few time-saving machines. The sources of supply of raw

materials, wood, lumber, minerals, fuel, and available tillable land are the stock in trade of the world. We should work for the intelligent management of forests, and for the economical use of fuels and ores. The climate, natural resources, and accessibility of each section should be taught together. Is it not better to know the boundaries of the coal and iron fields than of the states? to have on the mental map we form of a country the obstacles to commercial intercourse, the rainfall and climatic conditions, than the dividing lines of towns and counties? Does the botany we teach make a pupil eager to reforest land, plant fruit trees, and cultivate food plants? Does zoölogy inspire a pupil to do his little part in mitigating the mosquito plague; in destroying injurious and in cultivating beneficial insects? The meteorology we learn ought to make us satisfied with the weather we have and contented with our surroundings.

The business man or engineer must use his knowledge in the big and little emergencies of business life. It is perhaps just here that education for culture alone differs from a commercial or technical training. A culture knowledge includes a large amount of information, most of which is not at one's tongue's end—a *reminiscence*, as Plato calls it; while the business or professional man has a ready knowledge, or cognition, of his particular calling. Those who hold our fortunes and our lives in their keeping must have more exact knowledge than the accepted standard of culture demands. Absolute ignorance frankly admitted is far better than the vague knowledge of material processes and business method that makes a man think he knows when he does not. He must learn to inquire when in doubt, and to use every source of information. The lesson of the message to Garcia has been overdrawn. A man may be admired for his pluck and persistence; but fortune falls to the lot of him who informs himself thoroughly.

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